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DEVELOPMENT OF BOILED SAUSAGES WITH PROTEIN HYDROLYSATE FROM SECONDARY RAW MATERIALS

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Abstract

Currently, there is an increasing trend in the use of animal protein preparations derived from collagen-containing raw materials, such as pork and beef skins, as well as pork and beef trimmings, in meat product production. These preparations are valued for their high functional and technological properties, particularly their water-binding and gel-forming abilities, which significantly enhance the rheological properties of food products, including consistency, organoleptic qualities, and enrichment with dietary fibers. The aim of this study was to investigate the effects of a 10% protein hydrolysate emulsion on herodietic boiled sausages for the elderly. The results indicated that the experimental samples of boiled sausages contain 15.44% protein, 6.6% fat, 4.2% carbohydrates, and 71.1% moisture, suggesting that the inclusion of protein hydrolysate contributes to an optimal chemical composition for dietary nutrition. The moisture index also confirms an excellent sausage consistency. The peroxide number was monitored over 7 days, with results showing minimal change, from 2.0 meq/kg to 4.6 meq/kg, indicating stable oxidative characteristics. Additionally, the color stability was enhanced by the collagen emulsion. Products using collagen-containing emulsions displayed a higher concentration of tyrosine, ranging from 728.1 mcg/ml in the first three hours of hydrolysis to 392.5 mcg/ml after six hours, demonstrating improved protein digestibility due to the action of proteolytic enzymes like pepsin and trypsin. Thus, the incorporation of a 10% protein hydrolysate emulsion can be recommended for producing boiled sausages with enhanced nutritional and sensory properties.

Keywords: aging; older person; herodietic product; moisture-binding ability

Introduction

The increase in the world's population leads to an increase in the consumption of food, including meat. Meat production volumes are increasing by 4–5% annually. At the same time, only 50–54% of each carcass reaches the end consumer in the form of meat [1,2]. The rest goes into the category of industrial waste or secondary products [3,4]. Waste disposal involves environmental risks and additional costs, so recycling into value-added products is more acceptable [5,6]. Boiled sausages, also known as frankfurters [7] or hot dogs [8], are popular processed meat products enjoyed worldwide [9]. They are characterized by their smooth texture [10], savory flavor [11], and convenience [12]. Boiled sausages are typically made from a combination of finely ground meat [13], fat [14], spices [15], and additives [16], which are mixed and stuffed into casings before undergoing cooking processes such as boiling or steaming [17]. The popularity of boiled sausages can be attributed to several factors, including their versatility, affordability, and widespread availability [18–20]. They are commonly consumed as a quick snack, part of a meal, or as an ingredient in various dishes [21–23]. In recent years, there has been increasing interest in improving the nutritional profile of boiled sausages to meet consumer demands for healthier options [24]. Boiled sausages are a popular food product that is widely consumed in many countries around the world [25–27]. These sausages are distinguished by their delicate texture, unique taste, and many variations in recipes [28–30]. They are a source of

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protein, vitamins, and minerals, making them a popular choice to meet the nutritional needs of people of different age groups, including the elderly [31–34]. Elderly people have special nutritional needs associated with changes in the body, age restrictions, and loss of appetite [35]. In this context, the development of boiled sausages using protein hydrolysate from recycled raw materials represents significant potential for improving the nutritional value and popularity of these products among the elderly [36–38]. Studies have been conducted on the effect of protein hydrolysates on the postprandial glucose response in healthy adults, which may be useful in the development of products for the elderly [39]. Studies have been conducted to optimize the development process of low-sodium chicken cutlets with improved quality characteristics, which can also be applied to the development of boiled sausages using protein hydrolysate [40]. Optimization of pork meat sausage with a healthier fat content and improved sensory characteristics can also be applied to the development of cooked sausages using protein hydrolysate [41]. Various approaches to forming a healthier lipid profile in functional meat-based products, including boiled sausages, are considered. It explores the replacement of meat fats with non-meat fats to improve the nutritional composition of these products [42]. This study investigates the effect of natural antioxidants on the quality and shelf-life stability of frankfurters formulated with olive oil. It highlights the importance of using natural ingredients to enhance the sensory and nutritional attributes of boiled sausages [43]. The potential use of plasma protein hydrolysates as functional ingredients for preparing sausages is considered. It investigates the effect of including these hydrolysates on the physicochemical and sensory properties of boiled sausages [44].

Secondary products of the meat industry can become a rich source of protein and protein hydrolysates for use in the food industry, including in sausage production. Due to their chemical composition and functional properties, animal proteins are an alternative to proteins isolated from soy and can be used in meat products as a meat substitute, increasing nutritional and biological value, improving structural, mechanical, and organoleptic properties, enhancing the taste of meat, and reducing the cost of meat products [45]. Consumers today are guided not only by the taste qualities of the product but also by aspects related to health and environmental friendliness. The combination of these factors leads manufacturers to search for new formulations and ways to reduce waste [46].

The purpose of this study is to improve nutritional value, technological and organoleptic characteristics, and increase shelf life by adding collagen hydrolysate.

Materials and Methods

The objects of research are boiled sausage products using emulsions from collagen–containing raw materials (sausages beef + 10% hydrolysate). Protein hydrolysate was obtained by fermented hydrolysis of beef legs with a put joint. To carry out effective hydrolysis of protein substrates, the enzyme concentration was chosen: 5% by the enzyme BLT 7 [55]. The hydrolysis time is 24 hours at a temperature of 45 °C. The drying of the hydrolysate was carried out on a spray dryer Spray Dryer NSP-1500. Boiled sausages with the addition of protein hydrolysate are produced according to the standard technology of boiled sausages. Protein hydrolysate (in the amount of 10% by weight of minced meat) were added during minced meat cutting. The heat treatment was carried out to a temperature inside the loaf of 72 °C.

Methyl esters of fatty acids were analyzed on an Agilent 7890 gas chromatograph manufactured by Agilent Technologies (USA) with a flame ionization detector and a capillary column HP-Innowax 60m x 0.32mm x 0.5μm in a nitrogen current. The temperature gradient ranged from 100 to 260 °C at a rate of 10 °C/min. Injection volume was 1 μl, with a gas flow split of 1:100, and the detector temperature was maintained between 250 and 300 °C. We used a standard mixture of fatty acid methyl esters, Supelco No. 47885U, with automatic calculation of

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data for the content of C6...C24 fatty acids. The quantitative content of fatty acids was calculated using the method of internal normalization. Statistical processing of the results was conducted according to standard methodologies in line with the metrological characteristics stated in the methods. Where these were not available, the principles in paragraph 5.5 of RMG 76-2014 were applied, assuming a critical significance level of the null hypothesis (p) of 0.05 [56]. The digestibility of proteins in the studied products by digestive enzymes "in vitro" was determined by the Pokrovsky-Yertanov method. For samples of boiled sausage products, digestion was simulated according to the Pokrovsky and Yertanov protocol as follows. A control sample was prepared with enzymes but without the addition of sausage samples. To 0.5 g of the crushed sample, 25 ml of a freshly prepared pepsin solution (1 mg/ml concentration: 25 ml of 0.02 N hydrochloric acid solution, pH = 1.2, mixed with 25 mg of crystalline pepsin) was added, thoroughly mixed, and incubated at 37 °C for 3 hours. The remaining samples after pepsin digestion (25 ml) were neutralized by adding 0.65 ml of 2 N sodium hydroxide, after which 25 ml of a 0.02 N sodium bicarbonate solution (pH 8.2) and 25 mg of crystalline trypsin (final enzyme concentration in solution of 0.5 mg/ml) were added, followed by further incubation at 37 °C for 3 hours. Upon completion of digestion, the samples were immediately frozen at -40 °C for several hours. For protein concentration measurement, the samples were thawed, centrifuged for 20 minutes at 14,000 rpm, and the supernatant was collected. The protein concentration was measured using the Lowry method in triplicate for each sample. The concentration of the control sample was also measured, and its value was subtracted from the sausage samples to exclude the influence of enzymes on the protein content in the samples [57].

The color characteristics of the samples were determined using a Konica Minolta CM-2300d spectrophotometer calibrated using standard black-and-white calibration plates. The color values were expressed as L-lightness, a-redness and b-yellowness.

Results and Discussion

The evaluation of the chemical composition of experimental samples of boiled meat products did not reveal any abnormal deviations, and all indicators were in the generally accepted contents of this type of product (table 1).

Table 1. Physico-chemical indicators of herodietic boiled sausage products with the addition of collagen raw materials.

Name of the indicators to be determined	Unit of measurement	Test results
Mass fraction of moisture	%	71.1±7.1
Mass fraction of fat	%	6.6±1.0
Mass fraction of protein	%	15.44±2.32
Carbohydrates	%	4.2
Water-soluble proteins	%	3.20
Salt - soluble proteins	%	0.72
Alkali - soluble proteins	%	11.10
Cutoff voltage	kPa	38,5 ± 0,15
Limiting shear stress	Pa	887 ± 0,25

Attention is drawn only to the high content of carbohydrates and low fat content. Thus, with the generally accepted technology of production of this type of product, the fat content ranges from 10-20% absolute units, and carbohydrates less than 2-3%.

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The study of the dynamics of changes in the composition of protein fractions based on the results of comparative studies of the ratio of sarcoplasmic proteins, based on the extraction of sarcoplasmic proteins from muscle tissue with a buffer solution of low ionic strength and obtaining fractions of water-soluble, salt-soluble and alkali-soluble proteins, followed by the determination of their number by the Kjeldahl method, are presented in Table 1. The largest number of fractions in the experimental sample were isolated alkali-soluble proteins, the least salt-soluble, which does not contradict the literature data.

The strength properties of muscle tissue depend on the type, fatness, and variety of meat and change during processing. The tensile strength of muscle tissue is (10-20) x105 Pa, collagen fibers (2000-6500) x105, elastin fibers (1000-2000) x105. The tension of the cut of raw meat lies within (1,3-1,9) x105, after cooking it increases to (2,7-4,7) x105. The results of the experiment to determine the ultimate shear stress and shear stress of cooked sausages are presented in Table 1. It was determined that boiled sausage products using emulsions from collagen-containing raw materials are characterized by a rather delicate consistency, which is obviously due to lower values of BCC and VUS, in comparison with products without the introduction of collagen protein. Table 2 shows the main content of the fatty acid composition of the studied samples.

Table 2. Fatty acid composition of herodietic sausages.

Name of the indicator	Unit of measurement	Results
Myristic C14:0	%	1,7±0,4
Myristolein C14:1	%	0,1±0,4
Pentadecane C15:0	%	0,2±0,4
Palmitic C16:0	%	21,3±2,1
Palmitoleic C16:1	%	3,5±0,4
Margarine With 17:0	%	0,6±0,4
Heptadecene C17:1	%	0,2±0,4
Stearic C18:0	%	6,4±2,1
Oleic C18:1	%	30,1±2,1
Linoleic C18:2ω6	%	32,2±2,1
Linolenic C18:3ω3	%	2,8±0,4
Arachin C20:0	%	0,1±0,4
Eicosadienoic acid C20:2ω6	%	0,3±0,4
Tricosan C23:0	%	0,3±0,4

As a result of the conducted studies, out of 36 fatty acids, only 14 indicators were isolated in significant concentrations.

Currently, synthetic antioxidants are widely used to slow down the oxidation of lipids and proteins in the meat industry. However, consumers are concerned about these synthetic antioxidants because of their potential toxicological effects. Accordingly, natural antioxidants can be used because of their health safety compared to synthetic antioxidants. The dynamics of oxidative spoilage and cooked products are presented in Table 3.

Table 3. Dynamics of fat oxidation and protein oxidation (background) in herodietic sausages during storage.

Name of the indicators to be determined	Unit of measurement	Test results
Peroxide number (1 day)	meq/kg	2.0±0.2
Peroxide number (2 days)	meq/kg	2.1±0.2

Peroxide number (3 days)	meq/kg	2.6±0.3
Peroxide number (4 days)	meq/kg	2.9±0.3
Peroxide number (5 days)	meq/kg	3.3±0.3
Peroxide number (6 days)	meq/kg	3.9±0.4
Peroxide number (7 days)	meq/kg	4.6±0.5
Carbonyl compounds	nmol/mg of protein	96.5

When evaluating the results obtained, it can be concluded that the accumulation of the peroxide number is proceeding at a low rate, When studying the stability before and after exposure to light on the indicators of cooked sausages, the following values were obtained for the main characteristics of color: L-lightness, a-redness and b-yellowness. The data is presented in table 4.

Table 4. Color characteristics of herodietic sausages.

Color characteristics before exposure to light			**Color characteristics after exposure to light**			**Color stability, %**
L-lightness	a-redness	b-yellowness	L-lightness	a-redness	b-yellowness	
64,04±0,43	15,35±0,40	11,59±0,53	62,58±0,60	14,07±0,44	13,82±0,40	89,96±1,47

Thus, when determining the color stability of meat products to the effects of temperature conditions (heating to a temperature of 70-72 ° C), the influence of added chemical agents (according to the generally accepted formulation: chlorides, phosphates, etc.) and to determine the color stability during storage, color characteristics were studied and color stability was established. The obtained values for lightness and redness decreased slightly in the region of 2% and 8%, respectively. At the same time, yellowness, on the contrary, when exposed to light had higher values (by 20%) than before its exposure.

Conclusions

In conclusion, the physicochemical parameters of experimental samples of meat products were studied. During which the effectiveness of the use of protein hydrolysate was proved. The addition of protein hydrolysate in an amount of 10% improves the consistency and nutritional value of cooked sausages. The data obtained allow us to recommend these boiled sausages for the diet of the elderly.

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